TURNER

Efficiency Tests of
Hoisting Appliances

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EFFICIENCY TESTS OF HOISTING APPLIANCES

...BY...

CHARLES PHILIP TURNER

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE
IN MECHANICAL ENGINEERING

IN THE
COLLEGE OF ENGINEERING
OF THE
UNIVERSITY OF ILLINOIS
PRESENTED JUNE, 1904

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

CHARLES PHILIP TURNER

ENTITLED EFFICIENCY TESTS OF HOISTING APPLIANCES

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Mechanical Engineering

L. P. Breckenridge

HEAD OF DEPARTMENT OF Mechanical Engineering

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EFFICIENCY TESTS OF HOISTING APPLIANCES.

OBJECT.

It is the object of this investigation to actually measure the efforts and loads of several different types of hoists and from them to determine the actual efficiency of the hoists.

Curves of efforts and efficiencies are plotted showing how they vary under varying loads.

THE DYNAMOMETER.

In order to measure the effort, it was necessary to build some form of dynamometer which would give the effort.

After a study of existing dynamometers, the design shown on a following page was made and the dynamometer built in the shops of the department.

This dynamometer, as can readily be seen from the drawings, consists of two discs which rotate relative to each other and in so doing deflect the coil springs, connecting them. The amount of this relative rotation is read from the scale attached to one of the discs, over which a pointer on the other disc moves.

CALIBRATION OF DYNOMETER.

The dynometer was graduated to read pounds of effort on the 18-inch crank. The graduations were determined by holding the dynometer in a vise by the socket and suspending standard weights from the handle. In order that the arm of the weight be equal to the length of the crank arm, it was necessary that the weight act at right angles to the crank. This condition was fulfilled by keeping

[illegible]

the crank horizontal when loaded. This was determined by means of a small level. After the vibrations of the load had ceased and the crank been found to be horizontal, the graduation was marked by a scratch on the scale plate. This scratch was then stamped with the number corresponding to the number of pounds suspended from the crank arm.

APPLICATION.

In applying the dynamometer to jib cranes, the crank of the crane was removed and the socket of the dynamometer slipped on the shaft, the crank of the dynamometer taking the place of the crane crank.

In order to apply this dynamometer to chain hoists, it was necessary to have some form of windlass so that the power could be applied tangentially instead of by direct pull.The drawings for this apparatus are shown on a following page. The windlass was bolted to the floor, the hauling chain put over the windlass pulley and drawn tight by moving the carriage of the hoist along its transverse track. The hauling chain then made some acute angle with the horizontal and the windlass was out of the way of the load. The pulley of the windlass must, however, be in the plane of the hauling pulley of the hoist, which was determined by plumbing. Picture on following pages show the application of the dynamometer to both jib and chain hoists.

TESTS.

Tests of two job cranes and four chain hoists were made.

GENERAL METHOD OF MAKING TESTS.

In making the tests one general method was followed in all tests. The hoist was loaded with pig iron until a sufficient effort was required at crank to give a reading, viz. above 15 lbs. The load was then raised and readings of effort taken at each revolution of the crank. The load was raised through the range of this hoist, thus giving a varying number of efforts for the different hoists , depending on the reduction in the gearing. In the jib cranes it was necessary to raise the load twice in order to get a sufficient number of effort readings to obtain a good average. This was repeated for each load.

The loads were, generally, varied by 250 lbs. at a time as shown by data. In some of the tests the limit of the dynamometer prevented the loads from running up to the rated capacity of the hoists; others were tested to rated capacity.

METHOD OF CALCULATION.

In calculating the efficiency, the work of the load was divided by the work of the effort, i.e. if W = load, E = average effort for that load, X = distance through which load acts, Y = corresponding distance through which effort acts, then Efficiency = $\frac{WX}{EY}$.

One revolution of the crank was taken as the distance through which the effort acted and the corresponding distance through which the load moved was calculated from the ratio of the gearing. These calculations are made under each test.

PLOTTING OF CURVES.

Two curves were plotted, one of efficiency and one of effort. These are plotted as ordinates on a load base. For the convenience of any future reference to these tests, the efforts plotted were reduced to the effort which would be required in the actual working of hoist, i.e. for the jib cranes to efforts at 14-inch crank, which is length of crane crank in chain hoists to pull on hauling chain.

CALIBRATION OF DYNAMOMETER.

After making several tests, the dynamometer was calibrated a second time to see if the springs had varied. The calibration is given on the following page. The springs were found to have varied slightly from the graduation, although the variation does not seem to follow any law. The variations were therefore grouped into four groups and the average of the group taken as the correction for the range of effort corresponding to the group.

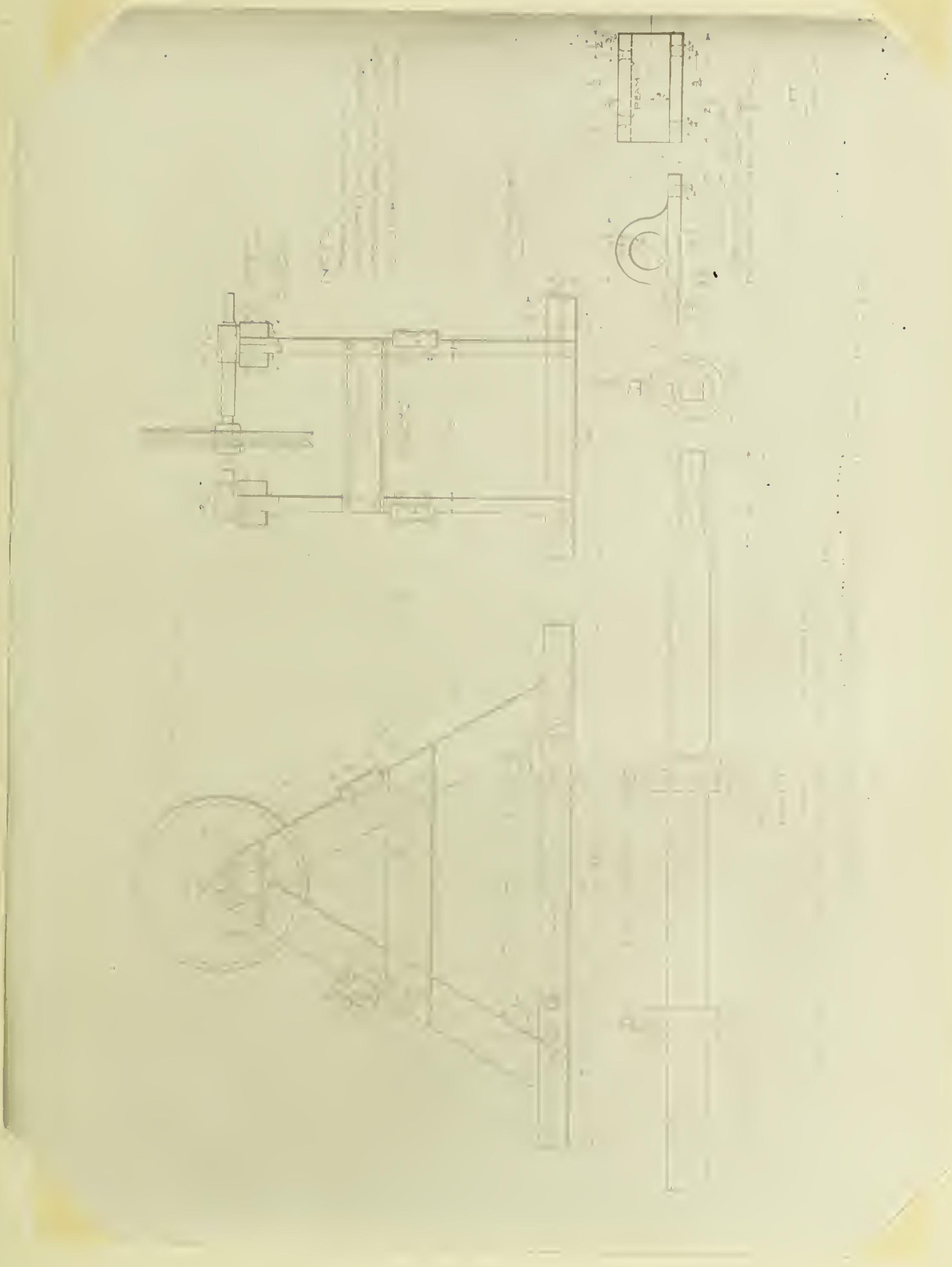
The following are the corrections which were made:

All efforts under 17.5 lbs. subtract 1 lb.
All efforts between 17.75 lbs. and 32.25 lbs.(inc.) subtract 2.04#
All efforts between 32.5 lbs. and 37.6 lbs. (inc.) " 1.63#
All efforts between 38.0 lbs. and 50 lbs. (inc.) " 2.66#

This correction will be applied throughout all the tests, it being assumed that the variation took place during the first few applications.

CALIBRATION OF DYNAMOMETER.

Load on crank.	I.	II.	III.	IV.	Av.	Variation.
15		16	16	16	16	1
16		18		17.5	17.75	1.75
18		20	20.5	20.	20.16	2.16
20	22	22	22.5	22.	22.12	2.12
22			23.5	24.	23.75	1.75
23		25	25.5		25.25	2.25
25	26.5	27	27	27	26.87	1.89
27						
28		30.5	30	30	30.16	2.16
30	32.5	32	32.	32.5	32.25	2.25
31		32.5			32.5	1.5
32						
33		34	35	35.5	34.8	1.8
35	38	37.5	37.5	37.5	37.6	1.6
36		39		38.5	38.75	2.75
37						
38		41	41	41.25	41.08	3.08
40	46	42.5	42.5	42.25	42.41	2.41
41		43.5		43.3	43.4	2.4
42				44.5	44.5	2.5
43		46.5	45.25	45.5	45.75	2.75
44			46	46.5	46.25	2.25
45	47.5		48		47.75	2.75
46	49	49.25	49	49	49.08	3.08
47	on stop	on stop	on stop	on stop	on stop	


BEAM

PORTABLE JIB CRANE. PROPERTY OF M. E. DEPT.

SIZE 3A. CAPY. 3000 LBS.

DESCRIPTION.

This crane is a small jib crane of 3000 lbs. capacity, size 3A, built by the Franklin Portable Jib Crane Co., Franklin, Pa. This crane had a 5/16 in. chain, one end of which was fastened at the outside end of the jib. From this point it passed down through the hook pulley, then up over a series of three pulleys in the jib. These three pulleys had a lateral motion along their shafts, equal to the length of the drum, in order that the chain might be wound on drum in a single layer. From these pulleys it passes to the drum to which the other end is fastened and upon which the chain is wound. The picture of this crane shown on a following page will show the direction of the chain as well as other details.

GEARING.

A small gear with 14 teeth keyed to the crank shaft drives a 72-tooth gear keyed to shaft with drum. Diameter of drum is 3 inches; to center line of chain is 3 3/4 inches.

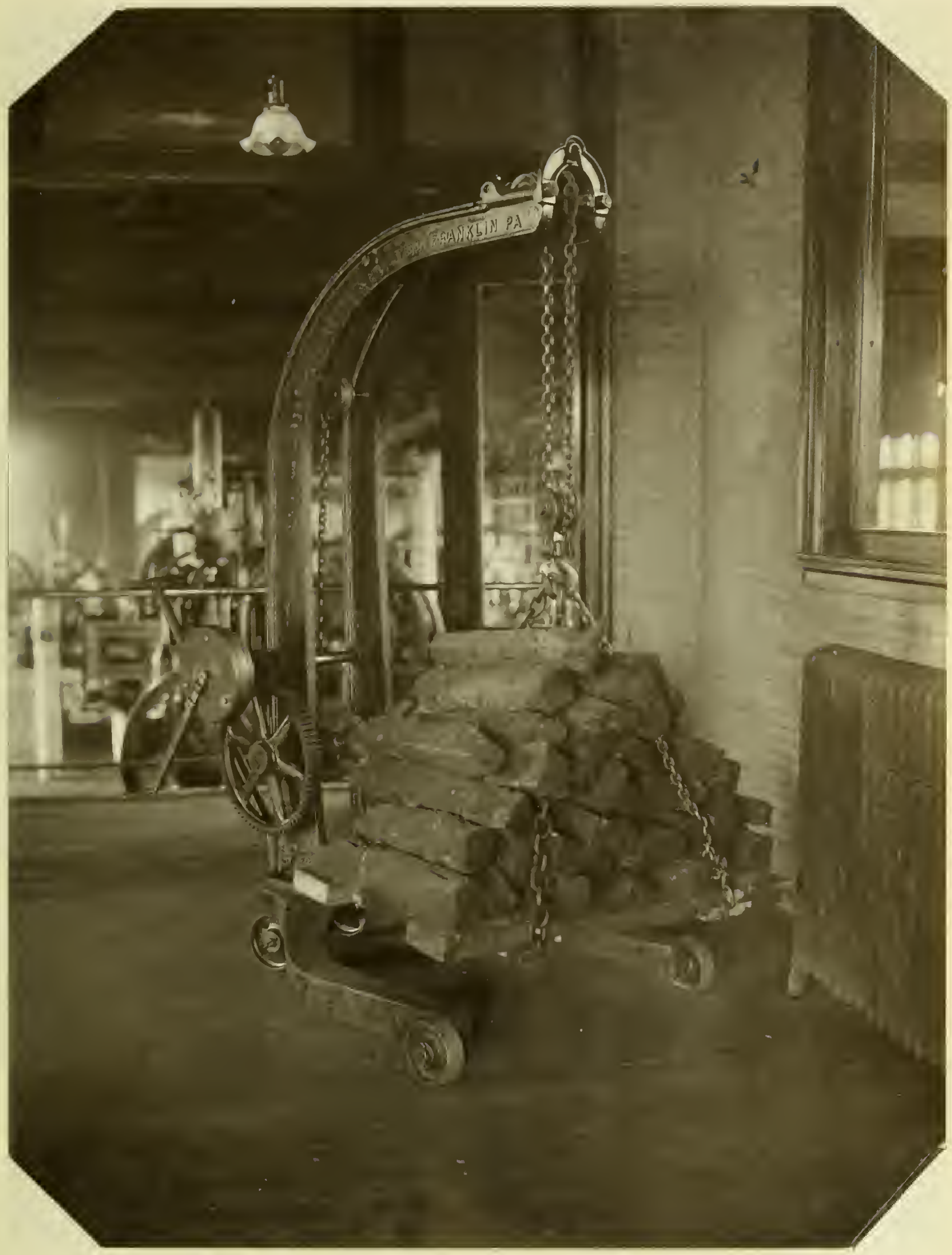
REDUCTION.

One revolution of crank is equal to 14/72 revolution of drum. Effort acts through circumference of 36 in. circle, equal to 113.0973 inches or 9.4248 feet. Circumference of 3 3/4 in. circle is equal to 11.781 inches or .98175 feet. Then for one revolution of crank or while effort is acting through 9.4248 ft., the load will run through 1/2 x 14/75 of .98175 ft.= .0955 ft.

(1) Wk. of load = load x .0955 ft.lbs.

(2) Wk. of effort = effort x 9.4248 ft.lbs.

Efficiency = $\frac{(1)}{(2)}$.



APPLICATION OF DYNAMOMETER TO JIB CRANE.

TEST OF FRANKLIN PORTABLE JIB CRANE. E. E. LAB.

Built by the Franklin Portable Crane and
Hoist Co., Franklin, Pennsylvania.

Size 3A. Capacity 3000 lbs.

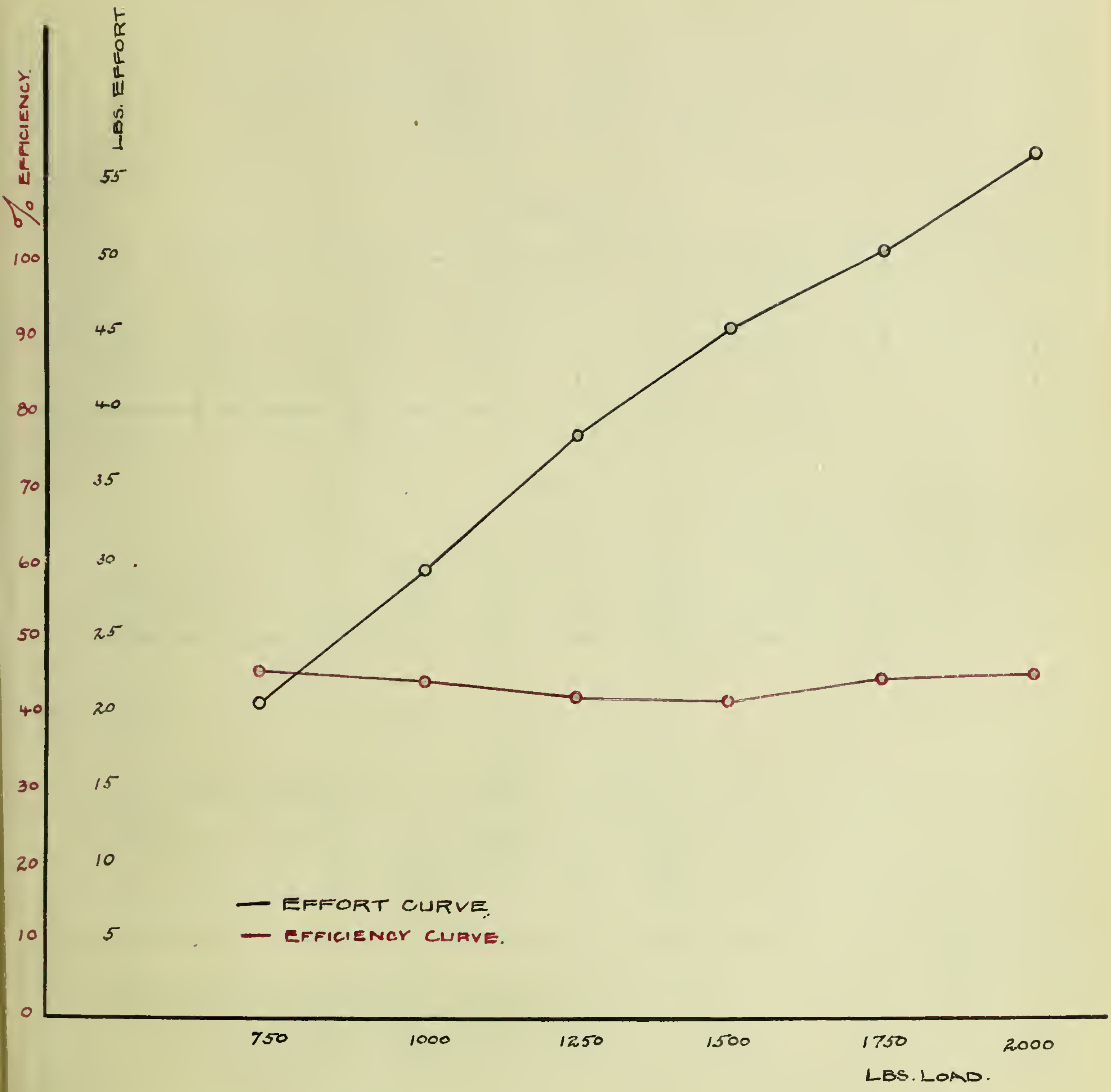
Loads.	730 lbs.	1000 lbs.	1250 lbs.	1500 lbs.	1750 lbs.	2000 lbs.
1	18	22.5	32	31	42	47
2	16	25.	31	40	41	43
3	15	25	30	41	43	49
4	19	25	31	40	42	47
5	20	27	29	36	43	43
6	18	28	33	38	41	47
7	16	23	34	36	43	50
8	20	28	30	37	41	48
9	17	23	28	37	41	46
10	17	30	35	36	40	47
11	19	25	32	40	46	50
12	20	30	30	35	44	46
13	17	22	32	36	42	46
14	20	25	30	33	45	49
15	16	25	30	38	40	48
16	16	21	31	40	46	46
17	19	25	31	37	48	50
18	20	22	31	47	43	47
19	21	21	31	40	44	49
20	20	25	32	32	41	43
21	21	22	30	33	42	46
22	22	27	32	35	45	49
23	18	28	35	37	40	50
24	18	25	27	33	38	49
25	16	23	31	42	32	48
26	16	25	38	36	41	47
27	18	22.5	30	37	41	46
28	15	24	33	38	44	48
29	17	22.5	33	38	43	45
30	18	23	34	39	43	47
Average.	18.1	24.8	31.5	36.9	42.2	47.2

FRANKLIN PORTABLE JIB CRANE. E.E. DEPT.

SIZE 3A. CAP'Y 3000 LBS.

SUMMARY.

Load. lbs.	730	1000	1250	1500	1750	2000
Effort on 18 inch crank lbs.	18.1	24.8	31.5	36.9	42.2	47.2
Effort on 18 inch crank. corrected. lbs.	16.1	22.8	29.9	35.3	39.5	44.5
Effort on 14 inch crank. lbs.	20.7	29.4	38.4	45.4	50.8	57.2
Work of load. ft.lbs.	69.6	95.4	119.1	143.	167.	190.9
Work of effort. ft.lbs.	151.7	215.	282.	342.	372.	419.
Efficiency per cent.	45.9	44.4	42.3	41.9	44.9	45.6



EFFORT AND EFFICIENCY CURVES

OF

FRANKLIN PORTABLE JIB CRANE

SIZE 3A. CAPY. 3000 LBS.

PORTABLE JIB CRANE. PROPERTY OF E.M.BURR.

SIZE B. CAPY. 2 TONS.

DESCRIPTION.

This is a small jib crane of two ton capacity, size B, built by the Franklin Portable Jib Crane and Hoist Co., Franklin, Pa. This crane is exactly similar to the size 3A crane just described, except for capacity and ratio of gearing.

GEARING.

A small gear with 14 teeth keyed to crank shaft, driven in a large gear with 68 teeth, which is keyed to shaft with drum. Diameter of drum is 4 1/2 inches, or 5 1/2 inches to center line of chain.

REDUCTION.

One revolution of crank is equal to 14/68 revolution of drum. Effort acts through circumference of 36 inch circle in one revolution, equal to 113.0973 inches, or 9.4248 feet. Circumference of 5 1/2 in. circle is 17.2788 in. or 1.43991 ft. Then while effort acts through 9.4248 ft., load moves through

1/2 x 14/68 of 1.4399 = .14822.

(1) Wk. of load = load x .14822

(2) Wk. of effort = effort x 9.4248

$$\text{Efficiency} = \frac{(1)}{(2)}$$

Effort on 14 in. crank = effort on 18 in. crank x $\frac{18}{14}$.

TEST OF FRANKLIN PORTABLE JIB CRANE.

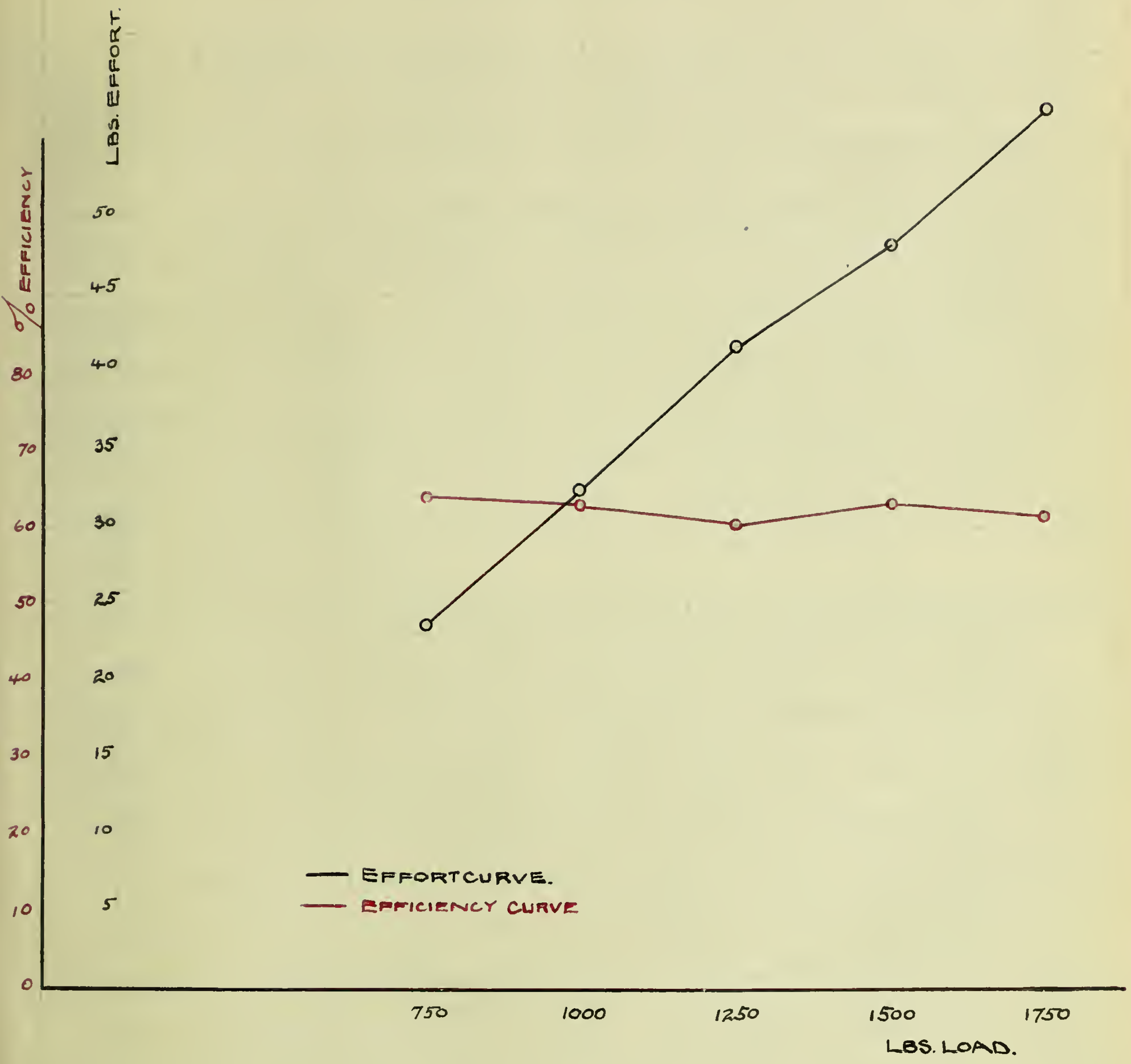
Loads	750 lbs.	1000 lbs.	1250 lbs.	1500 lbs.	1750 lbs.
1	20	27	35	32	45
2	21	30	30	34	46
3	16	30	34	42	48
4	22	25	35	40	44
5	20	27	32	32	49
6	21	26	37	42	50
7	20	27	35	44	50
8	20	25	34	40	46
9	19	26	32	40	43
10	22	30	32	41	48
11	20	27	33	43	48
12	21	25	35	40	47
13	16	25	35	41	47
14	22	27	34	40	48
15	22	27	32	42	45
16	21	40	36	40	45
17	22	29	36	42	47
18	21	25	36	42	49
19	21	29	36	41	45
20	20	28	36	41	45
21	21	28	34	42	49
22	21	25	35	43	50
23	20	24	32	41	48
24	20	26	32	40	45
25	21	30	34	41	46
26	21	28	36	38	45
27	22	28	35	40	48
28	21	25	33	42	49
29	21	28	32	41	47
30	16	26	37	40	50
Average	20.4	27.1	34.1	40.2	47.2

FRANKLIN PORTABLE JIB CRANE.

SIZE B. CAPY. 4,000 LBS.

SUMMARY.

Loads. Lbs.	750	1000	1250	1500	1750
Readings of effort. lbs.	20.4	27.1	34.1	40.2	47.2
Efforts corrected for scale. Lbs.	18.4	25.1	32.5	37.5	44.5
Efforts on 14 in. crank. Lbs.	23.6	32.3	41.8	48.2	27.2
Work of load. Ft.lbs.	111.	148.3	185.4	222.5	259.
Work of effort. Ft.lbs.	173.5	236.	306.	353.3	419.5
Effort. Per cent.	64.	62.8	60.5	63.1	61.8



EFFORT AND EFFICIENCY CURVES
OF
FRANKLIN PORTABLE JIB CRANE
SIZE B CAPY. 4000 LBS.

FRICTION IN WINDLASS.

In determining the friction in the windlass the chain was loaded on one side of the pulley with loads increasing at the rate of ten pounds at a time as shown by data. The turning effort was measured by a spring balance attached to the handle of the crank. Four sets of data were taken as shown, and the average was taken as the required effort. In determining the effort due to friction, the static effort required to balance the load was calculated by multiplying the load by the pulley radius and dividing by the length of the crane arm. The difference between this theoretical static effort and the average actual effort was taken as the effort required to overcome friction.

These friction efforts were plotted on a chain tension base as shown by points. The curve is an average straight line of the determined points. In order to apply this correction, the chain tension for the various efforts of the tests were calculated and referred to the curve to determine the amount of correction.

Since the determination of the chain tension involves the uncorrected effort, it was necessary to make a double approximation in order to determine the correction. The uncorrected effort was used to determine the chain tension, this chain tension was used in determining the correction, the correction was made and chain tension figured for corrected effort. This chain tension was then used to determine the correction which should be made. This correction was made and this effort taken as actual effort required.

FRICTION OF WINDLASS.

DATA.

	I.	II.	III.	IV.	Aver.	Static	
Loads.	Efforts.	Efforts.	Efforts.	Efforts.	effort.	effort.	Differences.
10	5.5	5.	5.5	5.5	5.4	3.8	1.6
20	11.5	9.5	9.5	9.0	9.9	7.5	2.4
30	15.0	13.0	13.0	13.0	13.5	11.1	2.4
40	19.0	17.0	16.5	17.0	17.4	15.0	2.4
50	21.0	21.0	21.0	20.0	20.8	18.8	2.0
60	25.0	25.0	25.0	24.0	24.8	22.5	2.3
70	31.5	29.5	29.0	27.0	29.3	26.3	3.0
80	34.0	34.0	32.0	33.0	33.3	30.0	3.3
90	39.0	38.0	37.0	35.0	37.3	33.8	3.5
100	43.0	41.0	39.0	40.0	40.8	37.5	3.3
110	46.0	46.0	41.0	46.0	44.8	41.3	3.5
120	49.0	49.0	46.0	50.0	48.3	45.0	3.3
130	51.0	53.0	52.5	54.0	52.6	48.8	3.8
140	54.0	57.0	57.0	58.0	56.5	52.5	4.0
150	61.5	62.0	62.0	62.0	61.9	56.3	4.6

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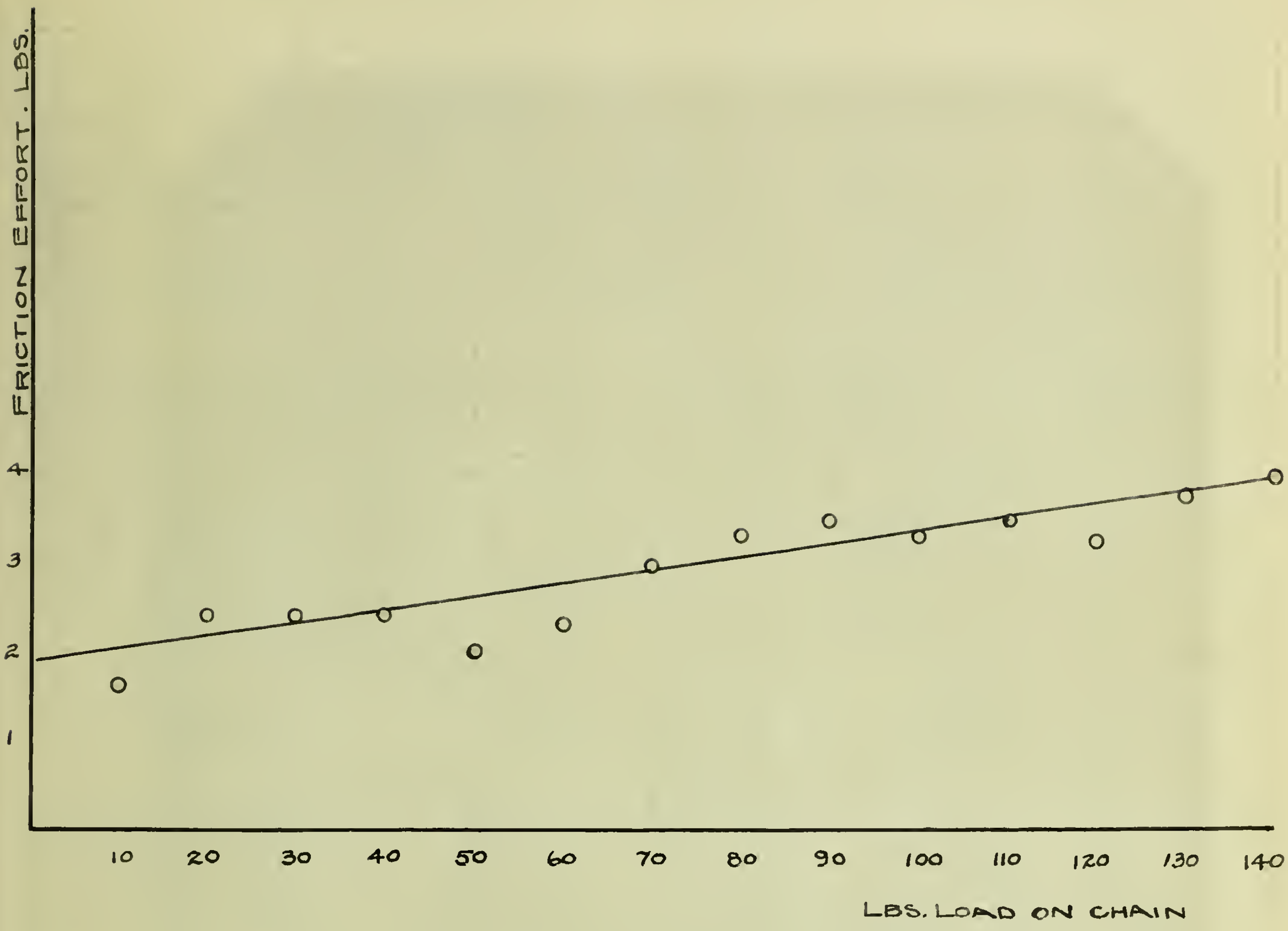
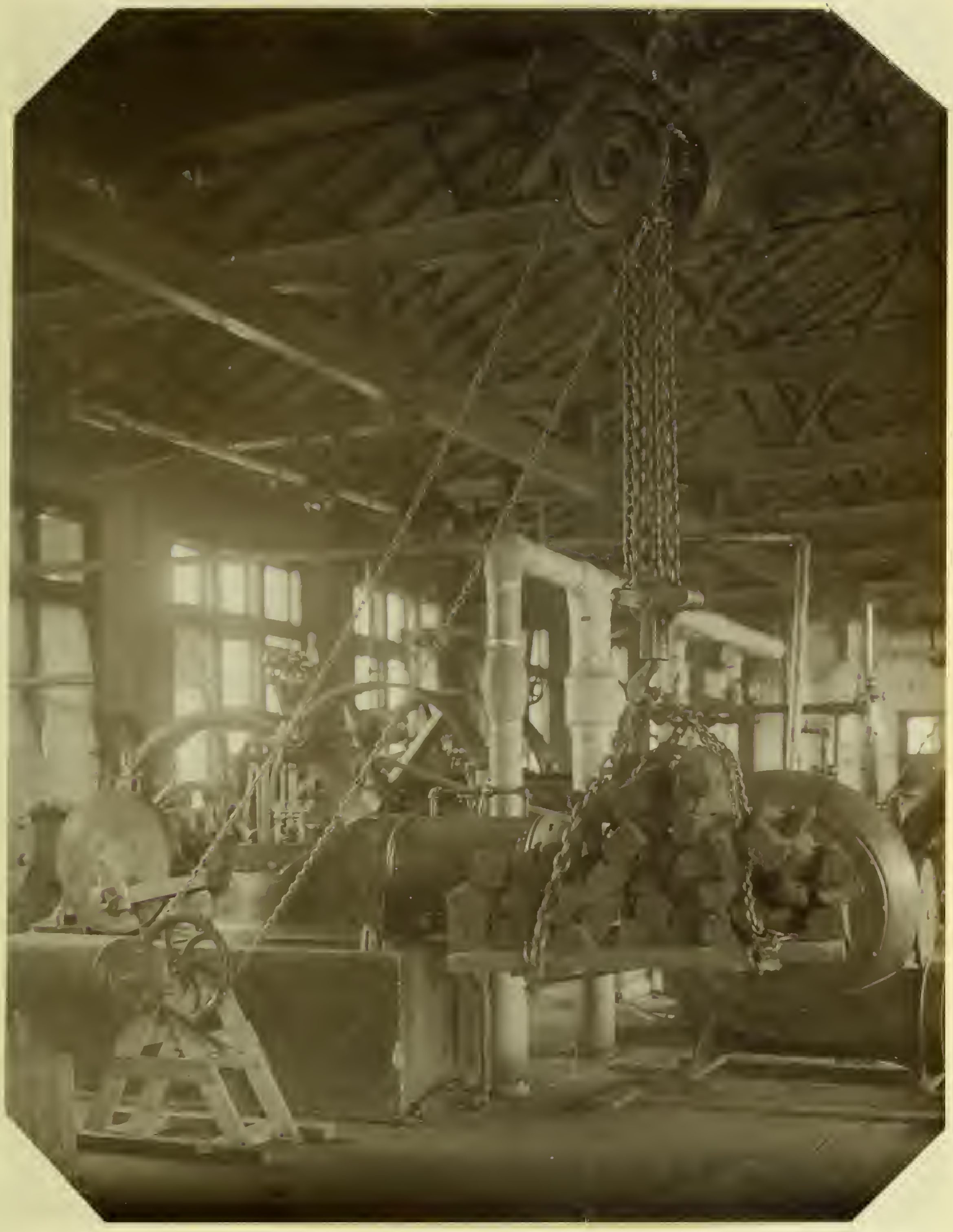


FRICTION CURVE OF WINDLASS.



APPLICATION OF APPARATUS TO CHAIN HOIST.

READING CHAIN HOIST. STEAM LAB. CAPY. 8000#

BUILT BY READING CRANE AND HOIST WORKS, READING, PA.

DESCRIPTION.

This hoist is used in the steam laboratory of the Mechanical Engineering Department, University of Illinois, with the traveling hand crane. The hoisting chain is made from 1/2 inch stock, the ends of which are fastened to frame of hoist. One part of chain is looped over hoisting pulley, passes down through climbing pulley, then to point of attachment at frame. For further details see drawing.

GEARING.

A small gear with nine teeth fast to hauling chain pulley drives a 29-tooth gear, which is keyed to a secondary shaft with another 9-tooth gear. This 9-tooth gear drives a 35-tooth anular gear which is fast to shaft with hoisting chain pulley. Diameter of hauling chain pulley = drum of windlass pulley = 13 1/2 inches to center line of chain.

Hoisting pulley has 6 pockets = 12 links.

Pitch of chain = 17 links in 2 feet = 1.4118 inches.

REDUCTION.

One revolution of crank = one revolution of hauling chain pulley = 9/29 x 9/35 = .0798 revolution of hoisting pulley.

Effort acts through circumference of 36 inch circle = 9.4248ft. in one revolution of crank.

Load acts through $9/29 \times 9/35 \times 6 \times \frac{1.4118}{12} = .05633$ ft.

Wk. of load = load x .05633

Wk. of effort = effort x 9.4248

Chain tens. $= \text{effort} \times \frac{18}{6.75} = 2.666 \times \text{effort}$.

TEST OF STEAM LAB. HOIST. CAPACITY 8000 LBS.

BUILT BY READING CRANE AND HOIST WORKS, READING, PA.

DATA.

Load	2000			2250			2500		
1	21	21	20	22	21	22.5	22.5	23.5	23
2	22	20	22.5	22	21	21.5	22.5	23	22.5
3	20	22	21	22	22	23	23	25.5	23
4	20	22	22	22.5	22	22.5	23	24.5	23.5
5	22	22	21	22.5	22.5	22.5	23	23	24
6	20	20	22	22.5	21	23	23	22.5	22.5
7	23	22	22	21	22.5	22	27	23	25
8	22	23	24	22.5	22.5	22	24.5	23	25
9	22	21	21	22.5	22.5	22	23	24	25
10	20	23	21	22	22	22.5	22.5	22.5	22.5
11	22.5	22	22	23	21	22	23	24	22.5
12	21.5	22	22.5	22.	22	22	24	23	23
13	22.5	22	22.5	24	22	22.5	23.5	25	25
14	20	22	22	22	22	22.5	22.5	25	24.5
15	22	22	22.5	22	22	22.5	24	22.5	23.5
16	22	22	22	22.5	22	25	23.5	24	23
17	22	22	21	22	22.5	22	26	24	25
18	20	21	22	22	23	22	22.5	22.5	22.5
19	22.5	22	22.5	22.5	22	22.5	24.5	22.5	23
20	23	22	22	22.5	22.5	22	25	23	24
21	22	22.5	22	22.5	22	21.5	25	24	25
22	21	20	22	22.5	22	25	23	22.5	22.5
23	22.5	24	22.5	23	22	22	24	22.5	24
24	22	23	22	22	21	22.5	24	25	25
25	22	22.5	20	24	23	22.5	25	25	24
Av.		20.4			22.4			23.66	

TEST OF STEAM LAB. HOIST. (CONTINUED)

DATA.

Load	2750			3000			3250		
1	26	27	24	30	28	28	32	31	36
2	26	27.5	26	29	28	30	32	30	32
3	26	30	24	28	30	28	32	29	31
4	26	24	26	29	30.5	32	31	33	31.5
5	24	25	26	31	29	30	32.5	32.5	33
6	27.5	25	28	30.5	30	30	32.5	30	31
7.	25	27.5	28	30	30	30	30	35	34
8	27	27.5	27	31	31	30	32	31.5	33
9	24	27	27.5	31	30	30	32.5	32	36
10	28	27	26	30	30	30	31.5	30	31.5
11	28	27	26	28	30	30	30	30	35
12	27	26	26	30	30	30	32	31.5	32.5
13	27	24	27	29	30	30	36.5	36	31.5
14	27	25	26.5	29	29	30	35	31	32
15	29	26	26	27.5	30	31	30	31	32
16	27	26	27	28	29	30	33	32	32.5
17	26	25	27.5	29	30	31	32	34	35
18	26	26	27	29	30	30	36	35.5	30.5
19	26	26	27.5	30	28	32	31.5	36	32
20	27	27.5	30	28	28	29	32	32	31.5
21	27	25	25	28	29	31	32	34	32
22	27.5	27.5	27.5	28.5	29	30	32	33	32
23	27.5	27	25	29.5	30	31	31	31.5	31.5
24	27	28	27	28	29	31	33	32.5	33
25	27.5	27	26	30	29	31	32.5	32	35
Av.		26.5			28.3			32.4	

TEST OF STEAM LAB. HOIST. (CONTINUED)

Load	3500			3750			4000		
1	35	30	35	36	36	41	37.5	34	41
2	32.5	30	35	36	35	37	36	40	42
3	32	33	37	37	39	37	40	42	43
4	37	34	32	35	40	40	40	41	36
5	33	34	34	40	41	41	37.5	36	42
6	35	33	38	37	36	37.5	40	39	38
7	32.5	33	39	37	40	37.5	40	41	40
8	33	32	34	34	35	36	41	35	40
9	32.5	32	37	36	38	36.5	40	40	41
10	33	34	32	41	40	37.5	36.5	41	42
11	32	36	35	41	36	40	39	42	42
12	32.5	32	32.5	35	40	37.5	43	38	39
13	33	33	36	35	35	35	37.5	40	40
14	31.5	33	37.5	36	36	36	40	42	41
15	34	37	34	32	35	40	39	36	39
16	34	34	33	33	38	36	41	37.5	37
17	31	32	31	35	40	36	36	42	39
18	32	37	35	37	40	35	37	43	40
19	32.5	36	32.5	35	38	40	39	36	41
20	32	36	37	36	37.5	41	39	41	43
21	31	32.5	36	36	34	33	37.5	36	35
22	33	35	32	36	40	36.5	40	39	40
23	34	32.5	33	38	39	40	40	40	41
24	33	36	33	37.5	37.5	37.5	39	42	42
25	33	32	38	35.5	36	42	36	33	43
Av.		33.8			37.4			39.4	

TEST OF STEAM LAB. HOIST. (CONTINUED)

Load	4250			4500			4750		
1	40	41	40	41	41	41	46	41	45
2	39	41.5	37	42.5	42	41	45	42	47
3	42	37	40	42.5	40	42	43	46	46
4	42.5	37.5	40	43	45	40	47	44	47
5	43	37	41	44	40	41	48	47	45
6	40	42.5	37.5	45	42	42	48	44	47
7	39	37.5	40	44	44	43	42	44	46
8	41	40	37.5	44	43	42	48	44	48
9	39	38	41	40	41	43	47	47	46
10	40	40	41	45	41	42	47	48	42
11	38	39	39	42	40	42	46	46	45
12	41	39	41	42	45	41	45	45	44
13	38	41	40	41	40	42	46	44	43
14	40	42	46	43	40	42	44	43	42
15	40	40	42	40	40	41	47	45	47
16	40	38	40	48	41	40	47	42	43
17	40	41	41	40	41	41	45	43	44
18	40	39	40	43	40	42	42	43	44
19	40	42	41	42	42	40	48	47	48
20	41	39	39	42	41	43	43	46	43
21	39	39	42	42	41	40	45	46	45
22	40	40	38	43	42	42	42	42	47
23	40	41	41	42	41	41	46	45	48
24	39	38	40	44	40	41	47	48	48
25	37	38	40	42	40	40	46	46	46
Av.		39.8			41.8			45.3	

TEST OF STEAM LAB. HOIST. (CONCLUDED)

Load		5000	
1	48	46	46
2	46	48	47
3	47	42	48
4	42	44	50
5	46	46	47
6	48	49	48
7	45	43	50
8	45	44	49
9	47	48	47
10	48	47	46
11	47	44	47
12	45	46	48
13	44	48	44
14	48	47	48
15	47	45	47
16	47	50	46
17	48	47	44
18	49	50	49
19	50	48	47
20	48	48	46
21	44	44	47
22	50	48	48
23	48	46	48
24	46	47	49
25	44	45	46
Av.		4.65	

TEST OF STEAM LAB. HOIST.

Capacity 8000 lbs.

SUMMARY.

Loads. lbs.	2000	2250	2500	2750	3000	3250	3500
Readings:	20.4	22.4	23.66	26.5	28.3	32.4	33.8
Corrected readings.	18.4	20.4	21.6	24.5	26.3	30.8	32.2
Corrected for fric.	16.1	18.3	18.9	21.7	23.4	27.8	29.2
Chain tens.	43.3	45.9	50.1	60.5	62.4	73.8	77.2
Wk. of load.	112.7	126.8	140.8	155.	169.	183.	197.
Wk. of effort	151.8	172.3	178.5	204.	220.3	262.	275.
Efficiency.	74.2	73.5	78.8	75.9	76.6	69.8	71.6

(Continued)

Loads. lbs.	3750	4000	4250	4500	4750	5000
Readings.	37.4	39.4	39.8	41.8	45.3	46.5
Corrected readings.	35.8	36.7	37.1	39.1	42.6	43.8
Corrected for fric.	32.6	33.5	33.8	35.8	39.2	40.3
Chain tens.	86.5	88.7	90.2	95.5	103.9	106.4
Wk. of load.	211.3	325.2	239.5	253.8	268.	281.8
Wk. of effort.	307.5	316.	318.2	337.5	369.7	380.
Efficiency.	68.8	71.3	75.3	75.3	72.6	74.2

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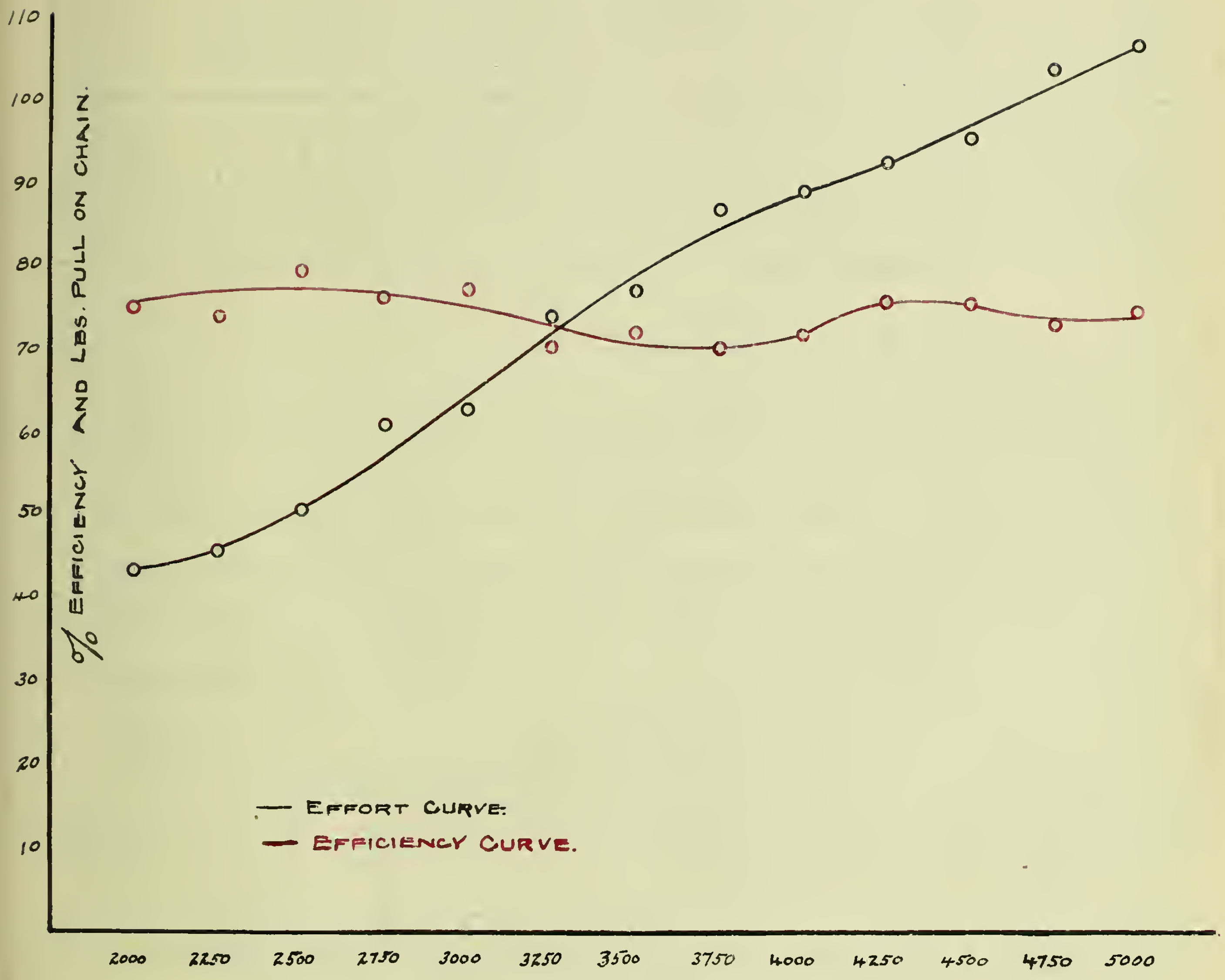

EFFORT AND EFFICIENCY CURVES

OF

READING CHAIN HOIST. STEAM LABORATORY.

CAPY. 8000 LBS.

READING CHAIN HOIST.

CAPACITY 6000 LBS. MACHINE SHOP.

DESCRIPTION.

This hoist is a 6,000 lb. capacity hoist used with the traveling hand crane in the metal shops. The hand chains are of 1/4 inch stock. The hoisting chain is made from 3/8 in. stock. This hoist is very similar to the one previously described and its action can be readily understood by reference to the drawing.

GEARING.

A small gear fast to hauling chain pulley and having 9 teeth, drives a 24-tooth gear, which is keyed to secondary shaft with another 9-tooth gear. This 9-tooth gear drives a 34-tooth annular gear which is fast to shaft with hoisting chain pulley. Hoisting pulley has 6 pockets = 12 links, pitch of chain = 1.143 in. = .o9525 ft.

REDUCTION.

One revolution of crank is equal to one revolution of hauling chain pulley, which is equal to 9/24 x 9/34 revolution of hoisting chain pulley.

Effort acts through 9.4248 ft. per revolution.

Load acts through 9/24 x 9/34 x .09525 ft. x 6 = .05673 ft.

Work of load = load x .o5673.ft.

Work of effort = x 9.4248

Chain tension = effort x $\frac{18}{6.75}$ = 2.666

TEST OF MACHINE SHOP HOIST.

OBSERVED DATA.

Loads	1500			1750			2100		
1	16	20	20	21	22	22	22	22.5	27
2	17	19	19	17	22	22	22	21	23
3	16	18	16	21	23	18	22	24	21
4	20	21	17	16	22	20	22.5	22	22
5	19	17	21	20	23	20	22	22	23
6	19	19	20	21	24	19	23	22	23
7	21	16	16	20	20	21	23	22	25
8	20	16	20	21	21	18	21	21	28
9	21	20	19	22	20	22	23	22	28
10	19	17	17	21	20	22	23	24	28
11	17	20	17	21	21	19	22	22.5	22
12	16	20	17	20	21	22	23	24	23
13	16	21	20	21	20	21	22	24	24
14	16	21	16	19	21	19	22	22.5	25
15	16	20	15	20	22	19	22	27	24
16	20	17	15	22	20	17	21	26	22
17	20	16	20	[illegible]	20	20	22.5	25	24
18	20	15	21	22	21	18	21	22	26
19	21	17	20	22.5	20	23	23	22	28
20	20	16	21	22	19	22.5	24	25	27
21	20	21	21	21	20	22.5	23	23	26
22	15	21	16	20	20	22.5	23	27	25
23	26	21	22	21	20	23	21	28	24
24	20	21	21	[illegible]	21	19	22	28	27
25	17	16	16	20	22	21	21	29	25
Av.		18.5			20.7			23.6	

TEST OF MACHINE SHOP HOIST. (CONTINUED)

OBSERVED DATA.

Loads	2450			2800			3150		
1	28	28	28	32	31	32	37	32	34
2	31	28	29	33	31	32	39	32	40
3	38	30	34	38	30	34	38	34	41
4	30	28	27	40	31	33	36	37	35
5	27	29	27	32	31	32	33	35	37
6	25	31	28	31	30	30	34	37	36
7	26	25	31	30	32	33	31	42	36
8	30	28	28	30	35	30	32	32	32
9	30	25	32	30	31	31	36	36	32
10	30	26	30	33	32	31	32	32	40
11	32	28	29	31	32	32	37	34	34
12	27	30	31	32	31	32	40	33	42
13	30	30	29	36	31	31	33	33	42
14	28	30	32	31	30	34	37	32	38
15	27	32	28	32.5	33	31	38	37	41
16	25	30	30	32	30	31	36	33	42
17	26	30	31	31	35	32	32	40	40
18	31	28	30	35	36	29	32	40	37
19	29	29	33	30	30	35	35	32	39
20	30	26	33	35	30	30	32	40	33
21	31	26	32	37	31	31	36	38	41
22	28	28	30	35	30	33	40	36	40
23	30	25	29	36	30	32	31	35	38
24	31	29	31	32	30	33	36	35	42
25	27	32	32	32	31	34	32	32	41
Av.	29.1			32.1			36.1		

TEST OF MACHINE SHOP HOIST. (CONTINUED)

OBSERVED DATA.

Loads	3500			3850			4250		
1	38	40	42	42	43	41	46	48	47
2	40	43	44	41	40	40	49	43	49
3	46	42	40	46	39	41	47	49	46
4	44	33	42	40	46	40	48	44	43
5	41	41	43	43	44	37	47	44	48
6	38	36	42	41	43	41	42	47	46
7	41	39	44	40	40	39	41	46	42
8	44	38	40	39	39	41	42	44	48
9	36	36	43	40	40	40	47	43	46
10	37	41	41	41	42	43	42	44	48
11	39	37	38	40	42	44	44	48	42
12	38	40	38	40	40	40	47	42	49
13	35	43	42	41	40	40	42	43	46
14	36	42	41	42	41	43	44	43	46
15	40	43	38	44	46	40	41	44	45
16	36	42	39	43	42	41	42	43	47
17	39	40	40	45	40	42	44	44	44
18	42	38	42	46	42	40	42	43	48
19	43	39	41	41	41	43	48	46	42
20	36	40	39	39	42	42	44	43	43
21	36	41	38	40	42	44	45	44	46
22	35	36	40	41	40	43	43	47	45
23	36	40	41	44	43	40	47	48	44
24	40	32	42	42	41	40	45	46	48
25	39	38	39	46	40	42	42	47	48
Av.	39.9			41.5			45.1		

TEST OF MACHINE SHOP HOIST. (CONCLUDED)

Loads	4500			4750			5000		
1	42	44	48	46	46	47	48	46	50
2	43	46	46	48	45	46	46	47	47
3	42	44	45	45	45	46	48	46	45
4	43	44	45	48	45	46	49	47	44
5	42	45	42	44	46	46	45	46	46
6	43	44	44	44	47	47	46	46	47
7	46	45	43	45	44	46	46	46	46
8	43	45	45	48	46	48	45	47	49
9	43	43	43	45	48	45	47	47	48
10	44	43	47	44	45	46	47	47	46
11	45	44	45	49	46	47	50	48	46
12	48	42	45	44	45	48	47	48	45
13	43	45	45	44	46	46	48	46	45
14	44	44	43	44	50	44	45	49	47
15	44	45	42	45	45	47	46	44	48
16	44	46	43	46	46	46	47	48	48
17	44	47	45	45	49	48	46	49	47
18	43	45	44	45	46	47	46	48	48
19	44	44	45	45	49	44	46	46	46
20	42	44	47	48	44	47	46	46	49
21	45	45	46	47	46	48	48	46	48
22	45	43	45	45	45	48	47	45	45
23	43	44	44	46	46	48	46	49	46
24	42	43	44	46	44	47	47	49	48
25	43	46	44	46	46	48	46	49	47
Av.	44.2			46.0			46.8		

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Started this test backwards from 5000 lbs. Chain stuck with 4250. Took off load, filed shaft and started with 1500 lb. load and worked up to 4500.

TEST OF MACHINE SHOP HOIST. CAPY. 6000 LBS.

SUMMARY.

Loads.	1500	1750	2100	2450	2800	3150
Effort readings.	18.5	20.7	23.6	29.1	32.1	36.1
Corrected readings.	16.5	18.7	20.9	26.4	29.4	34.5
Corrected for frict.	14.	15.2	18.3	23.5	26.4	31.4
Chain tens.	38.6	47.8	50.3	64.0	72.0	85.7
Wk. of load.	85.	99.2	119.	139.	158.8	178.5
Wk. of effort.	132.	143.	172.5	221.7	248.8	295.7
Efficiency.	64.3	69.3	69.	62.3	63.6	60.4

(Continued)

Loads.	3500	3850	4250	4500	4750	5000
Effort readings.	39.9	41.5	45.1	44.2	46.0	46.8
Corrected readings.	37.2	39.8	42.4	41.5	43.3	44.1
Corrected for frict.	33.9	36.5	38.9	38.2	39.8	40.5
Chain tens.	93.3	99.3	105.0	103.0	108.0	110.0
Wk. of load.	198.5	218.0	241.0	255.0	269.2	283.7
Wk. of effort.	319.8	344.0	367.0	360.0	375.	382.
Efficiency.	62.0	63.4	65.7	70.8	71.8	74.2

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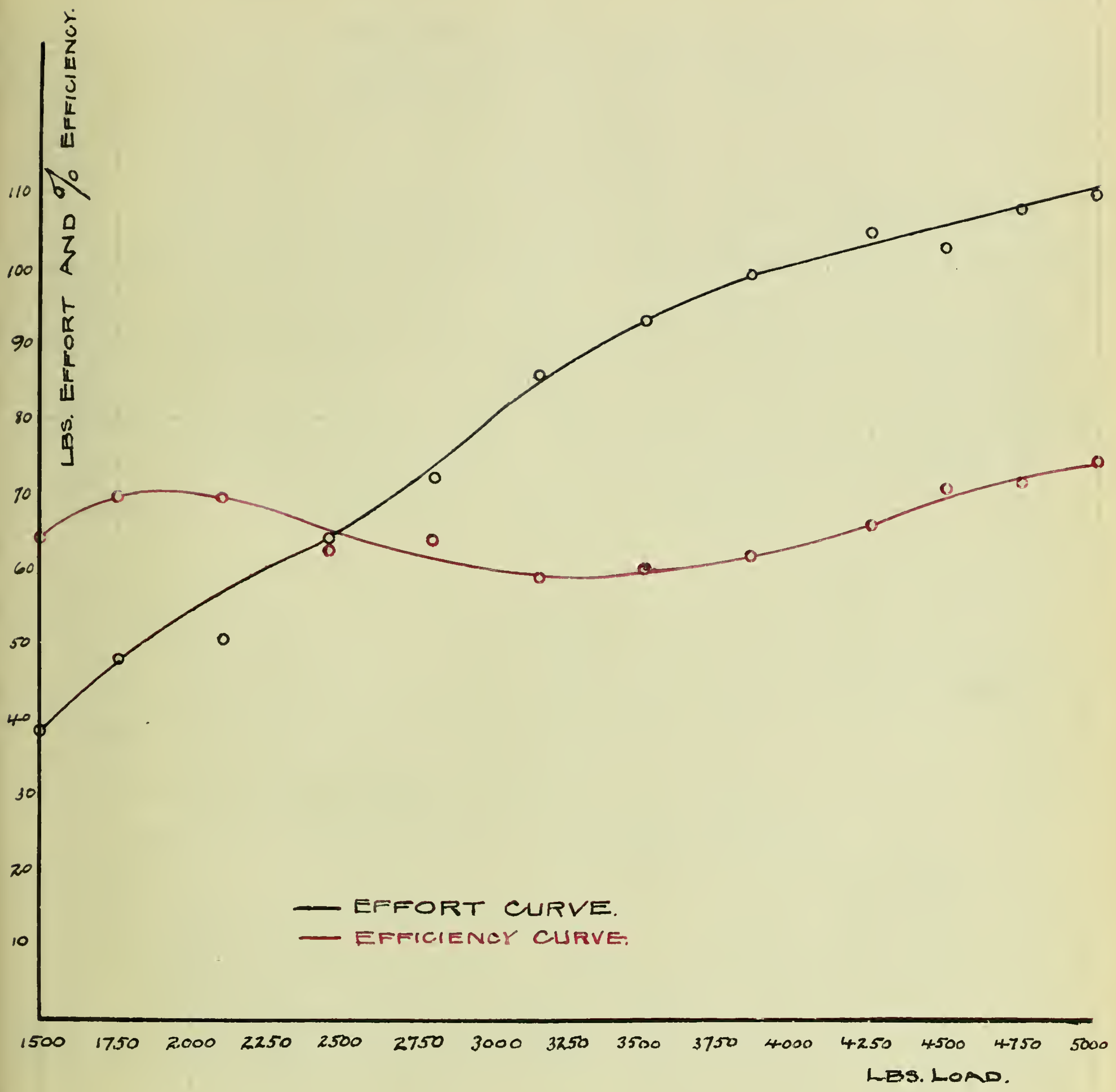

EFFOT AND EFFICIENCY CURVES
OF
READING CHAIN HOIST. MACHINE SHOP
CAPY. 6000. LBS.

WORM WHEEL HOIST. CAPY. 3000 LBS.

EDWIN HARRINGTON & CO., MAKERS.

DESCRIPTION.

This hoist is one kept in the stock room of the power plant. It has a screw fast to the hauling pulley which drives a screw gear fast to hoisting pulleys. There are two hoisting pulleys. Both ends of hoisting chain are fastened at the hook and the chain is looped over the two pulleys. See drawing. Pitch of screw, 1 1/4 in Screw gear wheel has 28 teeth. Hoisting pulley has 6 pockets = 12 links. Pitch of chain = $\frac{24}{23}$ in. = .0869 ft.

REDUCTION.

One revolution of crank = one revolution of hauling pulley = 1/28 revolution of hoisting pulley.

Effort acts through 9.4248 ft.

Load acts through 1/28 x 12 x .0869 = .03724.

Wk. of load = load x .3724.

Wk. of effort = effort x 9.4248

Chain tens. = effort x $\frac{18}{6.75}$ = 2.666

TEST OF WORM WHEEL CRANE.

Loads	1350			1500		1750		2000		2250	
1	20	20	15	20	21	22	22	25	29	27	31
2	21	16	15	20	21	22	23	30	30	28	31
3	19	21	16	17	22	23	24	31	30	29	33
4	20	17	16	17	21	27	23	30	30	30	31
5	18	17	17	16	20	23	23	32	29	31	32
6	16	17	16	20	20	23	25	31	30	34	31
7	16	16	17	21	21	25	26	25	30	36	32
8	17	16	19	21	21	24	24	29	30	35	31
9	17	16	16	20	21	24	22	30	29	29	33
10	16	17	20	20	23	24	23	30	30	31	35
11	20	16	16	21	19	23	22.5	30	31	30	31
12	19	17	17	20	20	23	22.5	30	30	32	36
13	16	17	20	22	21	23	23	30	31	28	31
14	16	17	16	20	20	24	25	29	29	30	30
15	15	16	17	22	21	22.5	24	30	30	35	30
16	17	16	15	22	20	23	23	27	30	32	31
17	15	20	16	20	20	23	22.5	28	30	34	33
18	16	15	16	20	21	24	23	29	30	32	35
19	15	16	17	20	20	24	24	27	29	31	30
20	16	18	18	20	19	22.5	24	30	28	30	29
21	16	18	18	21	20	23.5	22	29	30	33	32
22	16	16	16	21	21	24	23	31	29	32	32
23	17	16	16	22	21	26	25	28	27	31	32
24	16	15	17	21	20	25	23	29	28	32	31
25	18	16	16	17	19	24	22	30	29	30	32
Av.	16.9			20.3		23.5		29.3		31.5	

TEST OF WORM WHEEL CRANE. (CONTINUED)

Loads	2500		2750		3000	
1	30	30	37	36	42	40
2	35	35	38	34	40	40
3	35	32	35	38	35	36
4	32	31	32	31	37	37
5	30	32	35	32	38	38
6	31	33	37	37	42	36
7	35	32	36	34	41	34
8	30	34	33	35	35	36
9	30	32	33	32	40	35
10	31	31	34	32	37	37
11	32	32	35	35	40	40
12	32	32	32	32	45	40
13	31	30	35	35	40	38
14	31	31	37	34	41	35
15	36	30	35	35	42	36
16	33	32	31	33	40	38
17	32	30	31	35	37	40
18	31	31	35	35	36	41
19	32	31	35	33	40	38
20	30	31	32	33	41	36
21	32	31	31	35	40	37
22	33	30	32	38	38	35
23	30	30	33	36	36	40
24	31	33	36	35	40	40
25	33	32	32	33	40	42
Av.	31.7		34.4		38.4	

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TEST OF WORM WHEEL HOIST. CAPY. 3000 LBS.

SUMMARY.

Loads. lbs.	1350	1500	1750	2000
Scale readings.	16.9	20.3	23.5	29.3
Corrected efforts.	15.9	18.3	21.5	27.3
Corrected for frict.	13.5	15.8	18.8	24.5
Chain tens.	37.1	43.5	52.0	62.5
Wk. of load.	50.2	55.8	65.2	74.4
Wk. of effort.	127.3	149.	177.	231.
Efficiency.	39.4	37.4	36.8	32.2

(continued)

Loads. lbs.	2250	2500	2750	3000
Scale readings.	31.5	31.7	34.8	38.4
Corrected efforts.	29.5	29.7	33.2	35.7
Corrected for frict.	26.5	26.7	30.1	32.5
Chain tens.	73.4	74.0	82.7	88.8
Wk. of load.	83.8	93.0	102.4	111.6
Wk. of effort.	250.	252.	283.	306.
Efficiency.	33.6	36.8	36.2	36.4

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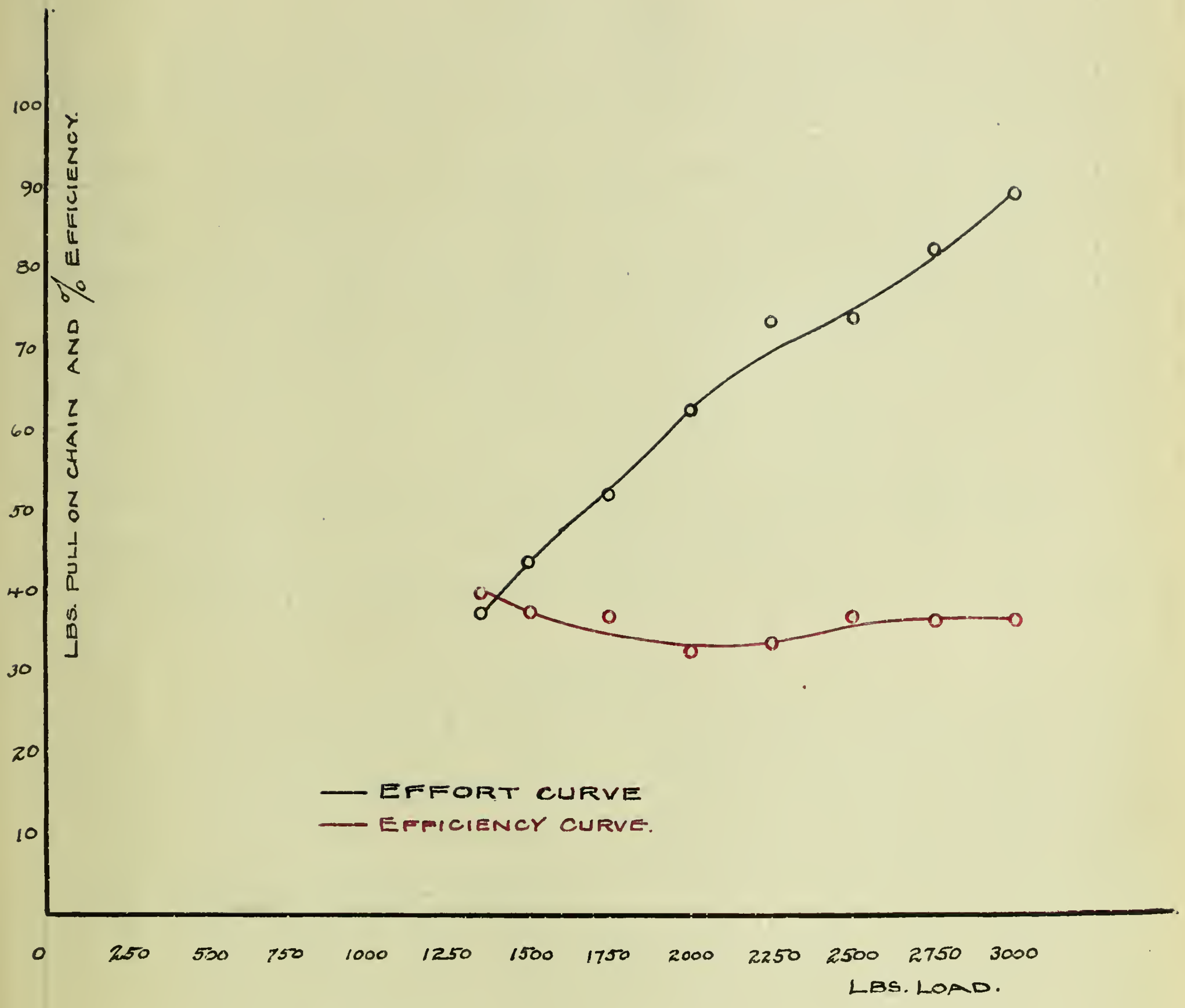


EFFORT AND EFFICIENCY CURVES

OF

WORM WHEEL HOIST

CAPY. 3000 LBS.

WESTON TRIPLEX SPUR GEAR BLOCK.

YALE & TOWNE MFG. CO., STAMFORD, CONN. CAPY. 2000 LBS.

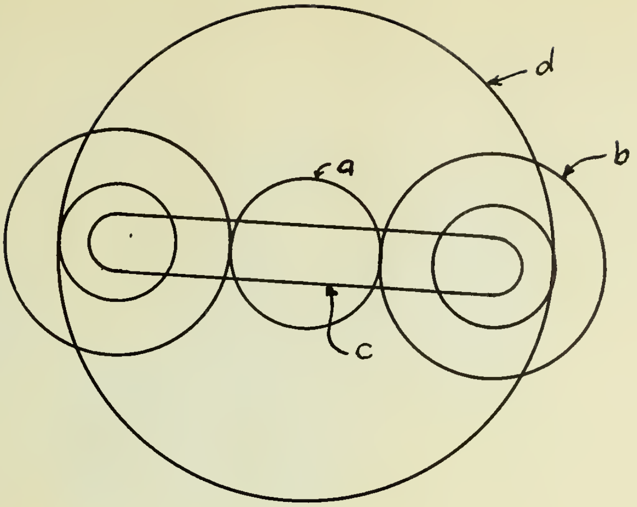
DESCRIPTION.

This is a block kept in the power plant store room to be used wherever needed. It has a small gear keyed to shaft with hauling chain pulley which drives two equal larger gears. Each of these gears has smaller gears fast to them and these travel around a large annular stationary gear and carry the hoisting pulley with them. The hoisting pulley has 5 pockets = 10 links. Hoisting chain is made from 3/8 in. stock and has a pitch of 24/23 in. = 1.0435 in. = .0869 ft. One end of chain is fast to frame, chain looped over hoisting pulley, and the load hook on other end. Hauling pulley, 10 in. dia. to cls.of chain.

For further details see drawings.

REDUCTION.

A 12-tooth gear drives two 29-tooth gears, which carry two 11-tooth gears. These 11-tooth gears travel around a fixed 42-tooth annular gear. In order to determine the reduction we will use a sort of tabular method.



Let "a" represent 12-tooth driving gear.

Let "b" " 29 " gear.

Let "c" " the arm.

Let "d" " the annular 42-tooth gear.

Consider the whole mechanism locked and give it a counter clock-wise revolution. Each link will receive a + 1 revolution, as shown by table.

a	b	c	d
+1	+1	+1	+1
$\frac{29}{12} \times \frac{42}{11}$	$-\frac{42}{11}$	0	-1
$1 + \frac{29}{12} \times \frac{42}{11}$	$-\frac{31}{11}$	1	0

Now hold "c" fixed and give "d" a clock-wise revolution. "b" will receive $-\frac{42}{11}$ revolutions and "a" $\frac{29}{12} \times \frac{42}{11}$ revolutions.

Adding, we find that "a" will receive

$1 + \frac{29}{12} \times \frac{42}{11}$ revolutions, and the crank will receive

$\frac{10}{13.5}\left[1 + \left(\frac{29}{12} \times \frac{42}{11}\right)\right]$ = 7.575 revolutions, or for one revolution of crank, the hoisting chain pulley will receive $\frac{1}{7.575}$ = .132 of a revolution, and the load will move through .132 x .0879 x 10 = .1147.

Work of load = load x .1147

Work of effort = effort x 9.4248

TEST OF WESTON'S TRIPLEX SPUR GEAR BLOCK.

YALE & TOWNE MFG. CO., STAMFORD, CONN. CAPY. 2000 LBS.

OBSERVED DATA.

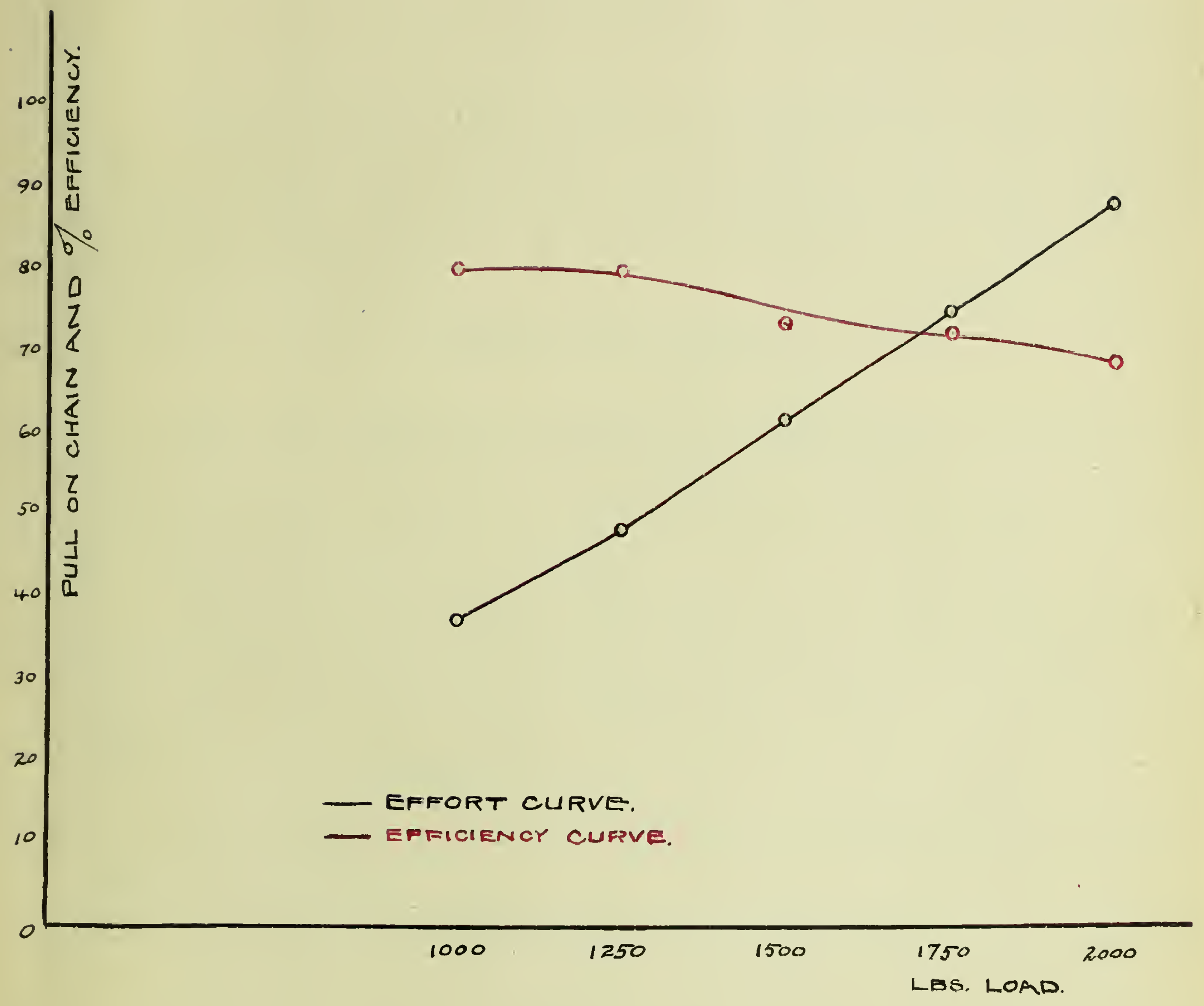
Loads	1000		1250		1500		1750		2000	
1	16	17	20	22	25	29	30	33	35	41
2	17	16	22	22	24	26	32	32	38	35
3	16	19	23	23	27	29	32	31	37	36
4	18	20	22	21	27	28	31	33	36	36
5	19	16	21	23	26	28	33	31	38	35
6	19	17	22	21	28	30	31	33	36	37
7	17	19	23	23	25	27	32	32	36	36
8	18	18	22	22	25	29	32	36	40	38
9	15	20	21	21	29	28	33	35	36	40
10	19	20	21	23	30	28	33	32	36	36
11	17	20	21	22	28	30	34	32	36	39
12	15	19	23	24	26	29	33	31	40	37
13	20	17	23	24	30	26	32	33	36	35
14	19	18	24	21	29	28	35	33	38	36
15	20	20	21	22	25	30	31	31	39	38
16	18	16	22	22	29	28	31	33	42	40
17	20	19	23	22	25	29	34	33	41	39
18	17	19	22	23	30	27	32	35	40	38
19	18	15	21	22	27	29	32	32	35	36
20	18	20	20	23	30	30	32	35	36	41
21	17	15	22	23	25	28	32	33	37	40
22	16	16	22	21	28	26	31	33	37	40
23	16	19	21	23	27	29	32	32	36	36
24	18	20	23	23	26	28	31	35	37	35
25	20	20	21	21	29	3[illegible]	30	33	36	38
Av.	18.04		22.1		27.7		32.4		37.4	

TEST OF WESTON TRIPLEX SPUR GEAR BLOCK.

CAPACITY 2000 LBS.

SUMMARY.

Loads. Lbs.	1000	1250	1500	1750	2000
Readings of efforts	18.04	22.1	27.7	32.4	37.4
correction for scale	16.	20.1	25.7	30.8	35.8
Correction for friction	15.6	19.5	24.9	29.4	34.2
Chain tension	37.3	48.	61.8	75.2	88.5
Work of load	114.7	143.3	172.	200.6	229.5
Work of effort	147.	184.	234.8	277.	322.
Efficiency	77.9	77.9	73.3	72.5	69.



EFFORT AND EFFICIENCY CURVES.

OF.

WESTON'S TRIPLEX SPUR GEAR BLOCK.

CAPY. 2000 LBS.

CONCLUSION.

The efficiencies do not seem to vary according to any law. They run approximately constant for the varying loads, the great variation being about 10% The lowest variation was in the jib crane and was about 4%.

RELATIVE EFFICIENCIES.

There is a marked difference in the efficiencies of the two jib cranes, probably due to the difference in the capacities and the workmanship on the two cranes.

The efficiencies of the chain hoists did not vary much except in the case of the screw hoist when the efficiency fell considerably below that of the other, showing that a screw is an inefficient method of self-locking.

The efficiency of the Weston Triplex spur gear block gave the highest efficiency.

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